Certification Memorandum

PARTS DETACHED FROM AEROPLANES

EASA CM No.: CM–21.A-A-001 Issue 01 issued 29 November 2018

Regulatory requirement(s): 21.A.3B(b), AMC& GM 21.A.3B(b)

In accordance with the EASA Certification Memorandum procedural guideline, the European Aviation Safety Agency proposes to issue an EASA Certification Memorandum (CM) on the subject identified above.
All interested persons may send their comments, referencing the EASA Proposed CM Number above, to the e-mail address specified in the "Remarks" section, prior to the indicated closing date for consultation.

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Log of issues

Issue	Issue date	Change description
01	29.11.2018	First issue

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1. Introduction

1.1. Purpose and scope

The purpose of this Certification Memorandum is to provide specific guidelines, limited to large aeroplanes, for evaluating whether an unsafe condition exists in Parts Departed from Aeroplanes events, hereafter referred to as 'PDA'. These guidelines can be applied by European DA holders.

This CM attempts to clarify how the Part 21 AMC that provides the definition of unsafe conditions should be interpreted when a case of PDA occurs.

Additionally, this CM provides harmonisation with the FAA on their draft policy PS-ANM-25-23 'Risk to Persons on the Ground from Objects Falling off Transport Category Airplanes' published by the FAA for comments in 2017.

1.2. Abbreviations

AIAA	American Institute of Aeronautics and Astronautics
AIA	Aerospace Industries Association
AMC	Acceptable Means of Compliance
CAAM	Continued Airworthiness Assessment Methodologies
CAT	Catastrophic
CM	Certification Memorandum
CS	Certification Specification
CVR	Cockpit Voice Recorder
DA	Design Approval
DFDR	Digital Flight Data Recorder
EASA	European Aviation Safety Agency
ELT	Emergency Locator Transmitter
FAA	Federal Aviation Administration
FH	Flight Hours
FOD	Foreign Object Damage
GM	Guidance Material
HAZ	Hazardous
PDA	Parts Departed from Aeroplanes

1.3. Definitions

PDA	In the context of this certification memorandum, parts detached from the aeroplane with no or low initial relative speed to the aeroplane.

2. Background

EASA shall issue airworthiness directives to correct any unsafe condition that is likely to exist, in accordance with Part 21.A.3B(b).

In the framework of Continued Airworthiness, PDA represent recurrent events whose consequences may lead to unsafe conditions.

The objective of the CM is to provide criteria to determine whether each potential PDA identified for an aeroplane model is an unsafe condition or not.

As per AMC 21.A.3B(b), an unsafe condition exists if there is factual evidence […] that:

(a) An event may occur that would result in fatalities, usually with the loss of the aeroplane(s), or reduce the capability of the aircraft or the ability of the crew to cope with adverse operating conditions to the extent that there would be:

(i) A large reduction in safety margins or functional capabilities, or
(ii) Physical distress or excessive workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely, or
(iii) Serious or fatal injury to one or more occupants

unless it is shown that the probability of such an event is within the limit defined by the applicable certification specifications, or

(b) *There is an unacceptable risk of serious or fatal injury to persons other than occupants, or* […]

PDA can be very different in their nature and location: doors, access panels, fairings, engine cowlings, fasteners, lights etc. may be involved, therefore determining whether an unsafe condition exists is not always straightforward. There are three main categories of potential consequences following PDA events that can be foreseen:

1. Damage and/or reduced functionality of the aeroplane (wing, fuselage, horizontal or vertical stabilizer structures, engine ingestion, control and other systems) potentially causing injuries to its occupants.
2. Injuries to people on the ground.
3. Damage to other aeroplane(s) (e.g. PDA encountered on runways) potentially causing injuries to its occupants.

As quoted above, the risk to the aeroplane and its occupants is covered by AMC 21.A.3B(b), paragraph (a), and further guidance is provided in GM 21.A.3B(b). The risk of injuring people on the ground or in other aeroplane(s) is addressed by AMC 21.A.3B(b), paragraph (b), according to which an unsafe condition exists when there is an ‘unacceptable risk’ of serious or fatal injury to persons other than occupants.

However, the word ‘unacceptable’ does not bound specific scenarios, and is open to interpretation, as no further guidance is provided in the AMC or GM to Part 21.

3. EASA Certification Policy

3.1. Objective

The objective of this CM is to provide guidance, limited to large aeroplanes, for evaluating whether each potential PDA event identified for an aeroplane model is, or is not, an unsafe condition.

The three main potential consequences of a PDA event, identified in Section 2, have been analysed in terms of their severity and probability of occurrence following a 'CS 25.1309-like' approach. They are assessed in Sections 3.2 to 3.4, and the conclusion is provided in Section 4.

This CM may be used only to assess PDA events in the framework of Continued Airworthiness. Although some PDA scenarios mentioned in this CM could be acceptable based on the observed rate of parts loss per FH, in general, the loss of parts should be prevented as much as possible.

This CM does not contradict certain accepted Initial Airworthiness requirements that address scenarios in which parts are assumed to fail and to depart from the aeroplane (e.g. fan blade loss, landing gear separation).

This CM covers the cases of parts that become detached from the aeroplane with no or low initial relative speed to the aeroplane.

Cases such as high energy rotating parts departing from the engine, or the inadvertent ejection of an ELT, or a DFDR/CVR, are therefore outside the scope of this CM.

3.2. SCENARIO 1: Damage to the aeroplane itself

In the case of a PDA, an unsafe condition can be caused by a direct effect of the detached part on the aeroplane, i.e. the loss of the function that this part provides; or by an indirect effect on the aeroplane, i.e. an impact on other zones of the aeroplane.

Concerning the direct effects of the PDA on the aeroplane itself, an assessment must show that the aeroplane functions compromised by the missing PDA, and the occupants of the aeroplane, are not adversely affected up to the point of experiencing an unsafe condition due to the loss of the part, following the guidance of GM 21.A.3B(b).

Similarly, concerning the indirect effects of the PDA on the aeroplane itself, an assessment must show that the potential impact of the part on other parts of the aeroplane does not cause an unsafe condition for the aeroplane.

In order to conclude that a potential unsafe condition, based on the hazard, is not unsafe based on the level of risk, it has to be shown, for both effects, that they meet the proper associated safety objectives. As per AMC 25.1309, any failure condition that would result in multiple fatalities, usually with the loss of the aeroplane, is classified as catastrophic (CAT). In addition, as per AMC 25.1309, any failure condition that would result in serious or fatal injury to a relatively small number of the occupants other than flight crew, is classified as Hazardous (HAZ). The safety objective associated with a CAT event is satisfied if the probability of occurrence per FH is less than 1E-9. The safety objective associated with a HAZ event is satisfied if the probability of occurrence per FH is less than 1E-7. There are other cases for which the severity of the event can be different.

The probability of a PDA impacting the aeroplane(s) depends on the trajectory that the released part follows, and the potential damage that a PDA impacting the aeroplane can cause depends on the force with which it may impact the aeroplane. The trajectories cannot be easily predicted, whereas the impact energy may be conservatively estimated.

For this potential risk, engineering judgement represents the most reasonable approach to be adopted. The location of the part in the aeroplane, its weight, size, and shape, and the configuration of the aeroplane are important parameters in order to identify the existence or not of an unsafe condition.

The combination of the trajectory of the part, the orientation of the part, and its impact energy should therefore be considered when assessing the side effects of PDA. The following aspects may be taken into account:

A. Trajectory of the detached part. Predicting the exact trajectories of detached parts is not generally possible, however some acceptable assumptions are that:

   — relatively light parts that do not behave as lifting surfaces may follow trajectories similar to the streamlines along the aeroplane;

   — parts that behave as lifting surfaces (like panels or undercarriage doors) will not follow the streamlines along the aeroplane;

   — non-lifting high-mass lost parts may not present a risk of hitting the aeroplane if the trajectory is mainly determined by gravity, or if the starting location on the aeroplane is such that the detached part is unlikely to impact the aeroplane;

   — the results of a statistical analysis of existing in-service data may be acceptable.

B. Damage to the impacted area. The potential damage depends on the energy of the detached part, the impact angle, the geometrical and material properties of the detached part, and on the characteristics of the impacted area itself. Conventional analysis is sufficient in most cases. Detailed dynamic modelling may not be required. The following steps may be accepted:

   — An estimation of the impact energy based on the mass and the maximum relative impact speed of the detached part;

   — An estimation of the impact angle and the worst orientation of the part;

   — An estimation of the worst possible extent of the damage;

   — Statistical analysis or in-service data used to substantiate the likelihood of a certain level of damage.

In general, the maximum energy of impact of a detached part can be conservatively estimated by considering the maximum estimated relative speed of the part and its mass. This is a conservative estimation, since the relative speed of the part is dependent on the drag coefficient of the PDA during its travel from the departure point to the impact point.

In-service experience: the results of a search into historical data going back to 1990, available at EASA, show that all the occurrences involving PDA have always been completed with uneventful landings and without any serious or fatal injuries for the occupants.

Note: some approval holders may wish to use existing bird strike compliance demonstrations as part of their assessment. As the impact dynamics for a bird versus a part impacting an aeroplane are generally different in terms of their densities, body shapes and consistencies, only a simple comparison of the energy level involved in the PDA event with the one defined in the bird strike requirements is not considered to be a sufficient substantiation for assuring that the impact will not prevent continued safe flight and landing.

3.3. SCENARIO 2: People on ground

PDA could produce serious or fatal injuries to people on the ground. The typical number of people hit by a part detached from an aeroplane can be assumed to be a small number. In the context of this CM, serious or fatal injuries to a person or a small number of people on the ground are considered to be events with hazardous consequences, extrapolating the severity definitions, as per AMC 25.1309, for people on the aeroplane to people who were not travelling on the aeroplane. Having a probability of occurrence that is lower than 1E-7/FH would therefore meet the safety objectives for a HAZ event, and hence, no unsafe condition would exist, as explained later in the text. This numerical threshold is in line with the EASA AMC 25.1309 safety objective associated with a Hazardous failure condition, which includes the possibility of 'serious or fatal injuries to a relatively small number of people'.

Several methods can be adopted in order to quantify the likelihood of causing fatal injuries to the people on the ground associated with PDA, however for all of them, the variables to be adopted are generally common:

— The density of population, with reasonable correction factors related to time exposure and shielding such as being indoors and shielded by, for example, buildings, or being on a means of transportation;

— The size and weight of the aeroplane(s) part concerned.

The likelihood/probability of causing a fatal injury is expressed as the combination of:

— The likelihood of a PDA event;

— The likelihood of a person being hit by the PDA;

— The likelihood that, if hit by the PDA, there will be fatal consequences.

The probability of a person being fatally injured when hit by PDA is set to 1, as a conservative assumption.

The probability of a person being hit by PDA (where PDA is considered to be large debris) is strictly connected to the time exposure calculated using the density of the population and factors such as the exposed area per person during both day and night.

The aforementioned evaluation could be made less conservative by refining the analysis and considering the size/weight criteria.

Following the different methods, the result is that the probability of fatally hitting people is in the order of magnitude of 1E-3 and, therefore, in order to meet a target of 1E-7 occurrences-per-FH, the probability of losing a single part per FH would need to be less than 1E-4.

Data retrieved from several large aeroplane manufacturers have been analysed. These data show a rate of loss of parts that is between 1E-6/FH and 1E-5/FH, resulting in an overall risk to people on the ground that is substantially lower than the proposed objective. The analysed data comprise different types of large aeroplane (long range, regional and business jets), which represent more than 90% of the EASA certified flying fleet. These data show a level of homogeneity, suggesting that the results that were obtained can be representative of an average large aeroplane design and fleet.

The conclusion is that the likelihood of fatally injuring people on the ground due to a PDA event is conservatively estimated to be close to the objective set in CS 25.1309 for system failures with a catastrophic effect, i.e. 1E-9/FH, and can therefore be considered to be acceptable regarding the probability objective of 1E-7/FH for impacting people on the ground. Furthermore, this is supported by the absence of any in-service events of people who were fatally injured as a consequence of PDA.

As a result, no unsafe condition has been identified for people on the ground from a quantitative point of view, or for the purpose of evaluating the need for mandatory corrective action.

In addition, an extrapolation of the parameters used in the assessment, together with the conservatism of some of the assumptions, confirms that this estimate will be valid in the mid and long-term.

A reassessment by the DA holder of a specific PDA case for a potential unsafe condition is expected when the loss of a specific part has a probability rate per FH that is significantly higher than the average probability rate, which is between 1E-6/FH and 1E-5/FH, as currently observed in the field.

3.4. SCENARIO 3: Damage to other aeroplanes/parts on the runway

A PDA, if lost on the runway, on a taxiway or in the airport area, may represent a threat to other aeroplanes (i.e. due to Foreign Object Damage - FOD). Statistics from field experience show that typically the areas that are most likely to be potentially damaged are aeroplane engines, tyres and wheels, causing economic impacts on maintenance costs, but usually with no significant impact on safety.

Nevertheless, depending on the damage that can be caused to another aeroplane, the severity may rise to CAT, and therefore the safety objective may be as low as 1E-9 occurrences per FH. As mentioned in Scenario #2, EASA has retrieved information from some European manufacturers on the parts lost, obtaining a rate of detached parts that is between 1E-6/FH and 1E-5/FH. Furthermore, considering the exposure time of the take-off and landing runs, the probability per FH of losing a part on the runway might be estimated to be about two orders of magnitude lower, i.e. between 1E-8 and 1E-7. This would mean hazardous outcomes would not be considered unsafe, but it is not possible to evaluate a priori the frequency of impacts on aeroplane of runway debris comprising PDA or the proportion of those events that may be catastrophic.

As a result, for this scenario, field experience remains the most valuable data on which to base a risk assessment.

In the recent history of European commercial air transport with aeroplanes that were certified under FAR/JAR/CS25, there have been non-catastrophic events that were caused by parts on the runway. For aeroplanes certified to earlier requirements, there is one record of an accident in which a part departed from an aeroplane with catastrophic results for a following aeroplane, although in that particular case it cannot be concluded that PDA was the sole contributor to the accident.

As a result of a quantitative assessment based on the above history, it can be concluded that the risk that PDA causes an accident to another aeroplane does not meet the criteria for an unsafe condition as defined in AMC 21.A.3B(b).

In terms of actions to address the threat from runway debris, in 2013, EASA published NPA 2013/02[1] that considered the need for new certification standards for protection of large aeroplanes against certain categories of threats, i.e. tyre and wheel failure, small engine debris and runway debris.

The Working Group involved in the preparation of the NPA reviewed existing threat models, outcomes of studies and in-service occurrences. With specific reference to runway debris (which may include PDA), the most frequent risk identified was damage to tyres and engines, the consequences of which were considered in the NPA to be adequately addressed by the proposed requirements to consider tyre, wheel and engine debris threats; subsequently introduced under CS 25.734 in CS-25 Amdt. 14. Of the other risks presented to aeroplanes by runway debris, no events were identified that caused injury. The working group considered that the protection afforded against tyre and wheel debris by the proposed requirements would also indirectly provide robustness and protection against runway debris thrown up by contact with the tyres. However, notwithstanding the potential safety benefits of the proposed threat models for wheel and tyre debris and engine debris, the NPA also recommended that airports improve FOD prevention as a complement to their current disposition of ICAO Annex 14.

As a result, in order to support the current satisfactory safety record and although the above assessments indicate an unsafe condition will not usually result from runway debris consisting of PDA, it is recommended

[1] https://www.easa.europa.eu/document-library/notices-of-proposed-amendments/npa-2013-02

that DA holders pay particular attention to preventing occurrences of PDA when the parts are prone to loss in the take-off and landing phases and of a nature that could cause tyre or engine damage.

A reassessment by the DA holder of a specific PDA case for a potential unsafe condition is expected when the loss of a specific part has a probability rate per FH that is significantly higher than the average probability rate, which is between 1E-6/FH and 1E-5/FH, as currently observed in the field.

4. Conclusion

In PDA events, given the current observed rates of loss of parts per FH, the risk of injuries to persons on the ground or damage to other aeroplanes, under the assumptions taken for this analysis, do not constitute an unsafe condition as per 21.A.3B(b). No specific assessment for a potential unsafe condition is expected for these scenarios unless a specific part shows a rate of loss per FH that is significantly higher than the average PDA rate that is currently observed in the field. In this latter case, the DA holder is expected to reassess the situation and to report to EASA if it is considered to be potentially unsafe (i.e. if the rate of loss per FH of this individual part is such that the conclusions of this CM, in terms of the existence or not of a potential unsafe condition, are invalidated).

As a consequence, the main scenario that a DA holder is expected to address is the possibility of the existence of an unsafe condition as per AMC 21.A.3B(b), paragraph (a), i.e. the possibility that a part detached from an in-service aeroplane creates an unsafe condition for the aeroplane itself. For this, the guidelines provided in Section 3.2 of this text and GM 21.A.3B(b) are expected to be followed.

5. Remarks

1. Comments or suggestions regarding this EASA Proposed Certification Memorandum should be referred to the Certification Policy and Safety Information Department, Certification Directorate, EASA. E-mail CM@easa.europa.eu.
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